Chapter 5

Innovation and Small Firms

Synopsis

Many of the technologies and industries seen as critical to the nation's future economic growth are closely identified with new technology-based firms (NTBFs). For example, biotechnology and computer software are industries built around new technologies that were largely commercialized by small businesses. The role of NTBFs as commercializers of new technologies is largely a U.S. phenomenon. Small businesses retain certain advantages over large businesses in the American commercial environment characterized by fast-moving technologies and rapidly changing consumer needs.

Since 1980, the federal government has instituted active policies in support of these dynamic NTBFs. Building on experiences in the states, Congress and the executive branch created new programs in which government and the private sector are partners in developing and deploying new technologies. These programs include the Small Business Innovation Research (SBIR) program, the Small Business Technology Transfer (STTR) program, the Advanced Technology Program (ATP), the Manufacturing Extension Partnership (MEP) program, and several financing programs for high technology companies administered by the U.S. Small Business Administration.

These programs stress commercialization potential, nonfinancial assistance, and better intellectual property rights protection. They represent only a small fraction of America's total investment in research and development (R&D), but in leveraging money to the public and private sectors, they have an economic impact far greater than that suggested by the program budget alone. Taken together, the programs represent an important commitment to the process that allows small technology-based businesses to use their unique competencies to address federal research needs, create new products and processes, and bring them to commercial markets.

New Technology-Based Firms' Contributions to the Economy

Most of the giant corporations that dominate the economic landscape began as small businesses whose founders developed radical new skills, knowledge, and information. In the early part of the 20th century, Henry Ford made the automobile an affordable consumer good with his use of the assembly line.

More recently, Bill Gates created a standard disk operating system for the personal computer. Since 1960, 29,358 high technology companies have been formed. About one-third have been software firms.

The role of small businesses as commercializers of new technologies is largely an American phenomenon.[1] The continual creation and marketing of new ideas by innovative new start-up companies steadily destroys the position of stagnant firms. This process is now thought by many economists to be fundamental to the prosperity of a capitalist economy. The continued ability of start-up companies to challenge industry leaders is thus of critical public policy concern.

One of the salient features of the U.S. innovation system is its enormous size. For a substantial portion of the post-World War II period, the national R&D investment of the United States was larger than the combined investment of all other member nations of the Organization for Economic Cooperation and Development.

The U.S. innovation system is unique also in that it has three key components: industry, universities, and the federal government. In 1995, U.S. expenditures on R&D totaled $171 billion. Companies accounted for 59.4 percent, the federal government for 35.5 percent, universities for 3.2 percent, and nonprofits for 1.8 percent.[2] Total R&D expenditures have grown steadily in the post-war period. However, since the end of the Cold War, the federal share of R&D has been declining, while the industrial share has grown to 2 percent of gross domestic product.

The share of industrial R&D performed by small firms increased from 5.6 percent in 1980 to 14.5 percent in 1995. Company-funded industrial R&D going to small firms has increased, but the corresponding federal share has remained at about the same level over the past decade. In 1993, of the $60.7 billion the federal government spent on R&D, small firms received 3.8 percent, up very little from the 3.5 percent they won in 1978 (Chart 5.1).

Despite their small share of federal R&D, new technology-based firms and individuals received 38 percent of all domestic utility patents granted in the United States in 1991. Given small businesses' small percentage of federal research funds, this output measure reflects a high rate of accomplishment.

In fact, in the modern economy, innovation remains largely the work of smaller firms. Though in the aggregate, NTBFs spend only a fraction of what large firms spend on total R&D, they produce more than half of the innovations. One study undertaken for the SBA identified a total of 8,074 innovations in 362 industries from 46 technical, engineering, and trade journals. Small firms were estimated to be responsible for 55 percent of the innovations, which included innovations at different levels of significance. A sampling of the most innovative industries reveals widely different patterns of small and large firm contributions (Table 5.1).

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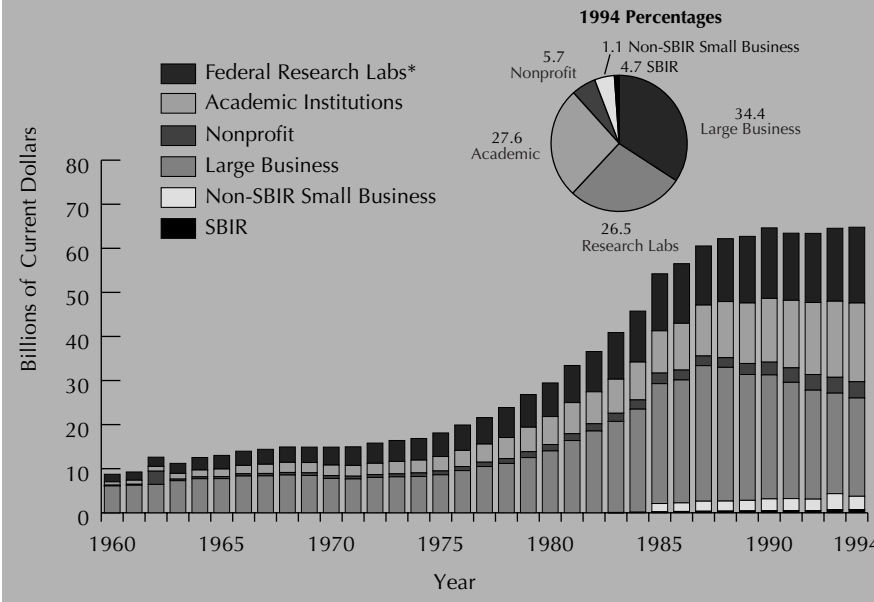
[1] Richard Nelson, *National Innovation Systems* (Oxford, England: Oxford University Press, 1993).

[2] U.S. National Science Foundation, *Science and Engineering Indicators* (Washington, D.C.: U.S. Government Printing Office, 1996), 4–6, Table 4.1.

Chart 5.1 *Allocation of Federal Research and Development Funding, 1960–1994.*



* Includes federally funded research and development centers.

Source: U.S. Small Business Administration, Office of Advocacy, based upon data from the National Science Foundation.

How can small firms' innovative activity be explained? While many explanations have been offered for the innovative prowess of small firms, one that is consistent with both entrepreneurship and fundamental U.S. American values is the role of property rights.[3] Small firms' greater innovative capacity may be explained by their relatively more generous property rights.[4] People must be able to keep a portion of the fruits of their labor or they will not innovate. An innovator in a large company often has very limited property rights protection: the new product generally belongs to the firm, not the employee who invented it. Creative employees have less incentive to work hard for the company. The less-than-perfect incentive structure in many large corporations can allow bureaucratic inertia to drive corporate decisions. Managers' and employees' interests lie in protecting their claims on the firm's cash flow. Small firms are better able to protect their property rights, which means there is more incentive to work hard.[5]

[3] David B. Audretsch, *Innovation and Industry Evolution* (Cambridge, Mass.: The MIT Press, 1996).

[4] In firms that concern themselves with basic scientific research, which includes many biotech firms, scientists have an incentive to innovate that goes beyond property rights. It is known as the priority of discovery that arises because of the recognition awarded by the scientific community for being first. In this milieu, the larger the investment in R&D, the more innovations that investment will tend to produce.

[5] See F.M. Scherer, testimony before the U.S. Senate, Committee on the Judiciary, Subcommittee on Monopolies and Commercial Law, February 21, 1988.

Table 5.1 *Number of Innovations by Large and Small Firms in the Most Innovative Industries, 1982**

Industry	Total Innovations	Small Firm Innovations	Large Firm Innovations
Electronic computer equipment	395	227	158
Process control instruments	165	93	68
Radio and TV communication equipment	157	72	83
Pharmaceutical preparations	133	13	120
Electronic components	128	73	54
Engineering and scientific instruments	126	83	43
Semiconductors	122	29	91
Plastics products	107	82	22
Photographic equipment	88	9	79
Office machinery	77	10	67

*Large and small firm innovations do not always sum to total innovations because several innovations could not be classified according to firm size.

Source: Keith L. Edwards and Theodore Gordon, *Characterization of Innovations Introduced in the U.S. Market in 1982,* report no. PB84-212067, prepared by The Futures Group under contract with the U.S. Small Business Administration, Office of Advocacy (Springfield, VA: National Technical Information Service, 1984). As reported in Zoltan Acs and David Audretsch, *Innovation and Small Firms* (Cambridge, MA: The MIT Press, 1996), table 2.1.

There are many incentives to work in addition to property rights. Corporate culture also affects motivation and incentives for hard work. For example, employees of Sun Microsystems (a large firm) have a commitment to succeed that is enhanced by the large number of people sharing it; that may be inspirational to the point of making people want to work harder. A small firm may not provide the commonly shared culture of a large organization and may threfore require more self-motivation to get new ideas out.

NTBFs gain their comparative innovative advantage by exploring new technological spaces that may have been overlooked by larger firms. In many industries small firms receive funding for such efforts. Regional networking facilitates this process and permits small firms to obtain and use knowledge more efficiently in order to make radical innovations. Because their research is closely tied to that of other institutions and firms, it diffuses quickly.[6]

[6] Larger firms may not explore new technological spaces, not because of neglect, but because of fear of "cannibalization"—having one's own new products steal market share away from one's established ones.

Knowledge is localized for both start-up and other firms, but start-ups are more closely tied into regional networks because they depend on networks for critical knowledge inputs. If knowledge flows are localized, then firms located in distant regions are excluded from knowledge networks. Where this occurs, large firms must get knowledge inputs internally.

Both small and large firms play important roles in innovative activity. Small firms tend to have the innovative advantage in industries with high technological opportunity and where large firms dominate. This suggests a division of labor between large and small firms. Small firms are superior in commercializing new knowledge; large firms are superior in their ability to appropriate returns from these innovations, either by buying property rights or acquiring the small firms.[7]

Thus, the greatest synergy might be achieved through continual mergers of new small firms with innovative products into large firms with international market access. For example, highly innovative small pharmaceutical companies are continuously absorbed into larger multinational firms as the industry is forced to become more efficient.

In the global economy, the fundamental driving force behind rising living standards is the ability to innovate. Radical innovations are just as likely to take place in small firms as in large firms because of the advantages that small firms offer in protecting property rights. Therefore, the continued entry of new technology-based start-ups into the economy is a crucial public policy issue.

Government plays an important role in small firm innovation by increasing small business access to the R&D infrastructure, diffusing risk, and providing capital. The SBIR and STTR programs help to ensure that NTBFs have access to the huge federal R&D infrastructure. The advanced technology and manufacturing extension programs help integrate the research into small firm networks. And Small Business Administration programs increase the pool of equity and lending capital. By strengthening the innovative capabilities of the small firm sector, these programs foster America's global competitiveness and technology-based economic growth.[8]

SBA Management and Financial Support for NTBFs

The federal government has played an active role in financing new high technology firms since the Soviet Union launched the Sputnik satellite in the late 1950s. In recent years, European and Asian nations and many U.S. states have adopted similar incentives. While these programs' precise structures have differed, the efforts have been predicated on two shared assumptions: that the private sector provides insufficient capital to NTBFs and that the gov-

[7] Wesley M. Cohen and Steven Klepper, "A Reprise of Size and R&D," *Economic Journal*, vol. 106, 1996, 925-951.

[8] Lee Preston and Charles O. Heller, *Small Business Economics*, Special Issue on Small and Medium-Sized Enterprises in the Global Economy, vol. 9(1), 1997.

ernment can identify firms where investments will ultimately yield high social and/or private returns.[9]

Small Business Development Centers

Congress created the Small Business Development Center (SBDC) program in 1980 to provide some of the management, technical, and research assistance needed to aid the start-up, expansion and successful operation of small businesses. The program fosters economic growth through job creation and generation of tax revenues. The SBDC network has grown over the last decade to include about 950 service delivery locations meeting the counseling and training needs of more than 550,000 clients annually throughout the 50 states, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands.

In addition to providing basic management, technical, and research assistance to pre-venture entrepreneurs and existing small businesses, a number of SBDCs are emphasizing assistance to technology companies. Specialized services include commercialization help, assistance to inventors and manufacturers, SBIR application assistance, and services to NTBFs. SBDCs have provided counseling to more than 100,000 small manufacturing firms over the last five years, including 23,000 in 1995 alone.

The SBA has also established an agreement with the U.S. Department of Commerce to establish SBDC field offices at manufacturing extension centers to improve the competitiveness of small and medium-sized manufacturers by providing management and marketing consulting and guidance. To date, field offices have been established at manufacturing extension centers in New York, Ohio, South Carolina, California, Minnesota, Michigan, and Kansas.

The following are examples of SBDCs working with technology-based firms.

ACCELERATE Technology SBDC, California

California's ACCELERATE Technology SBDC is one example of an SBDC that focuses on high technology businesses. The California SBDC has grown from one "technology center" to a variety of jointly funded activities around the state. The SBDC assembled potential investors, sales leads, venture capitalists, representatives of government and high technology industries, and SBDC clients at its Technology Showcase. The showcase was one of several innovative strategies that included a venture capital forum, coaching clients for investor presentations, co-sponsoring workshops on preparing successful SBIR/STTR applications, and introducing clients to potential investors and partners.

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[9] The rationale for such programs is discussed in depth in U.S. Congressional Budget Office, *Federal Financial Support for High-Technology Industries* (Washington, D.C.: U.S. Government Printing Office, 1985). For a review of the literature, see Glenn R. Hubbard, "Capital Market Imperfections and Investment," *Journal of Economic Literature*, 1995. For the long-run impact of these programs, see Josh Lerner, *The Government as Venture Capitalist: The Long Run Impact of the SBIR Program*, working paper 96-038 (Boston, Mass.: Harvard Business School, 1996).

In 1995, ACCELERATE counseled 269 businesses, creating 83 new high-paying jobs and saving 107 others, for an economic impact of more than $74 million—the entire federal cost of operating the SBDC program in FY 1995. In addition, the program introduced 128 clients to potential investors; 12 percent went on to face-to-face meetings. ACCELERATE helped five clients secure more than $10 million in equity funding.

For example, ISCHEM Corporation, a manufacturer of neural network computers for medical diagnostics, closed on a $5 million equity financing. With ACCELERATE's assistance the firm gained valuable introductions to investors, consultants, and strategic allies.

Another ACCELERATE client, XCORP, was featured in a recent issue of *Technology Transfer Week,* a showcase of global business opportunities in defense conversion and dual-use technology. With assistance from the SBDC, XCORP has developed alliances with the National Aeronautics and Space Administration (NASA) and the Department of Energy to manufacture XCAR parts in a new rapid prototyping plant.

South Carolina State University SBDC, South Carolina.

The South Carolina State University SBDC has worked with Westinghouse Savannah River Company in Aiken, South Carolina, to inform regional businesses of the technologies available from the Savannah River Site Laboratory. The SBDC continues to work with five technologies, three of which are nearing marketability. One is the "bone growth stimulator" that is currently going through the FDA approval process. When approved, it will be manufactured by a South Carolina firm, CTM Technology, and marketed by a Florida firm. This product is being evaluated in several overseas markets including Canada, Australia, and Asia. The product will reduce the time required for a broken bone to heal by 20 to 30 percent.

Financial Support for NTBFs

The U.S. Small Business Administration (SBA) has several loan programs that assist small businesses whose primary activity is in the high technology industry. Two programs that currently assist some 2,000 high technology businesses annually are the Section 7(a) and 504 loan programs (Table 5.2).

The Section 7(a) loan program authorizes the SBA to guarantee loans made by lenders to small businesses that cannot obtain financing on reasonable terms through normal lending channels. The SBA can guarantee 75 percent of the loan amount up to $750,000. For loans of $100,000 or less, the guaranty rate is 80 percent. The interest rate is not to exceed 2.75 over the prime lending rate.

Through certified development companies (CDCs), the 504 loan program provides long-term, fixed-rate financing to small businesses to acquire or construct facilities for their operations or to purchase machinery and equipment with a useful life of 10 years or more. Typically, project proceeds are provided as follows: 50 percent of the project cost is financed by an un-

Table 5.2 *SBA Financial Assistance to High Technology Businesses, FY 1993–FY 1996*

Fiscal Year	Number of High-Technology Firms Assisted			Total (Dollars)
	7(a)	504	Total	
1993	1,031	151	1,182	361,687,294
1994	1,374	163	1,537	434,007,374
1995	2,068	187	2,255	431,595,747
1996*	1,383	213	1,596	342,512,604

* First 10 months of the year.
Source: U.S. Small Business Administration, Office of Financial Assistance, 1996.

guaranteed bank loan, 40 percent by an SBA-guaranteed debenture that is sold to investors at a fixed rate, and 10 percent by the small business. The maximum SBA debenture is $750,000, except under certain circumstances when it can be up to $1 million. Job creation and retention is the main purpose of the program.

In addition to these established loan programs, the two-year pilot capital access program was conceived to help direct the SBA's limited loan resources to businesses that may have a greater impact on the nation's overall economic well-being. It is based in part on a proprietary computer-based market segmentation program developed by Citibank that identifies and targets businesses involved in the development and utilization of newer technologies, potential job creators, and prospective exporters. Minority-, women-, and veteran-owned firms are also targeted under this program. The program includes a mutually agreed upon set of credit standards and a streamlined loan application process. So far, nine loans for a total of $1,663,000 have been made to high technology firms under the program.

An SBA financing success story is that of Biosource International.

Biosource International, Inc., Camarillo, California.

Biosource International, formed in 1989, is engaged in the licensing, development, manufacture, marketing, and distribution of immunological reagents and test kits used in biomedical research. The company focuses its sales efforts on academic, industrial, and government laboratories. As of 1996, employment was at 53 with projections that another 18 employees would be needed within two years. Revenues for the 11 months ending November 30, 1995, exceeded $7 million. The project cost is $1.51 million to purchase a 27,000-square-foot building in which to locate this expanding business. The financing will be $745,000 from a non-guaranteed lender secured by a first trust on the building; an SBA-guaranteed debenture of $616,000 secured by a second deed of trust; and a $149,000 injection by the small business. This combination of public

and private capital allows the small business to conserve the working capital necessary to sustain its growth.

Angel Capital Electronic Network

A series of nine focus groups sponsored by the SBA's Office of Advocacy between September 1995 and March 1996 confirmed the existence of a significant gap in equity capital for rapidly growing firms needing between $500,000 and $1.5 million. Entrepreneurs can often raise amounts under $500,000 from their personal resources (investments, second mortgages, credit cards, families, friends, and colleagues). For amounts up to $1.5 million, however, it is very difficult to raise the third-party patient equity capital so essential to the success of rapidly growing high technology businesses.

Popular mythology has it that the organized venture capital industry has sufficient capital to meet the needs of high-potential small businesses, that the shortage is not of capital but of "good deals." The myth is both popular and false: the organized venture capital industry has always been a limited market. Fewer than 1,000 deals are consummated in a year and fewer than 100 are starting or seed deals. As the amount of funding flowing into the industry has increased, the number of deals has remain essentially static. The average size of a deal has increased dramatically: organized venture capitalists rarely fund deals under $3 million.

Many of the NTBFs with promising technologies, products, and markets need relatively small amounts of patient capital to commercialize and produce their products. These firms have traditionally turned to the informal private equity capital that goes under the name "angel capital." This market has been estimated at 30 times the size of the venture capital market.

Because angel capital is both informal and private, knowledge about the nature and extent of the market is limited. The Office of Advocacy's nine focus groups examined the problems associated with angel capital and its potential to meet the needs of rapidly growing small businesses. The focus groups confirmed that despite the essential role angel financing plays, the market has inefficiencies associated with a lack of organization and high transaction costs.

SBA's Office of Advocacy, in cooperation with the University of New Hampshire's Center for Venture Research, recently examined how the process could be improved. Clearly, the market would work better if the angel investors had access to more potential deals and the entrepreneurs had exposure to more potential investors. The trick was to design a system that would provide greater dissemination of information without notably increasing the potential for fraud and abuse.

The new system, unveiled in October 1996, is ACE-Net, the Angel Capital Electronic Network. ACE-Net covers eight of the most successful regional angel capital networks with a password-controlled, secured Internet network. The network will serve as a locator for serious investors and entrepreneurs interested in finding each other. A series of carefully crafted security mechanisms will help protect the process from fraud and abuse.

ACE-Net addresses the problem of high transaction costs by introducing a set of standard terms to reduce the time and cost involved in each transaction. The primarily university-based regional networks are ideally positioned to provide education and information about the angel financing process to potential angels and entrepreneurs. As the network begins to operate, it should increase the number of angels, the potential amount of angel financing available, and the efficiency of the process.

The Small Business Innovation Research Program

Federal research and development that strengthens the national defense, promotes health and safety, and improves the nation's highways and airports, is vital to the long-term interests of the United States and its citizens. The SBA, through the Small Business Innovation Research (SBIR) program and its smaller companion program, the Small Business Technology Transfer (STTR) program, helps ensure that innovative ideas developed by quality small businesses are a part of these efforts. These programs ensure that some $1 billion in federal R&D projects goes to small businesses each year. SBIR is an integral component of a national technology strategy and the primary access point for NTBFs to participate in federal R&D efforts.

In 1982 Congress passed the Small Business Innovation Development Act, authorizing the SBIR program. The nation had just undergone a long period of economic stagnation and policymakers were looking for new economic answers. International competition, particularly in producing and marketing technology, was growing more intense. The United States had the largest R&D effort in the world—a scale of scientific enterprise unequaled in history—and America's international competitors were becoming more successful at producing and marketing innovations derived from that research.

The SBIR program was designed to address these perceived problems in several ways. It increased the competition for federal R&D work by opening it to small businesses. The scope and funding of each project was designed to attract talented entrepreneurs. Projects were chosen to fulfill each government agency's requirements for innovative solutions to their technology-oriented problems. To improve the nation's economic competitiveness, the program was designed to encourage entrepreneurs to bring innovations derived from federal R&D into the marketplace.

Today's SBIR program is a competitive procurement activity designed to meet the R&D needs of the federal government. Each federal agency with an extramural R&D budget in excess of $100 million must designate a certain percentage of this budget for small business. The percentage increased from 2.0 percent to 2.5 percent in October 1996.

Ten federal agencies participate in the program currently: the Departments of Defense, Agriculture, Commerce, Education, Health and Human Services, Transportation, and Energy, the Environmental Protection

Agency, the National Air and Space Administration, and the National Science Foundation.

In the three-step SBIR process, small businesses can earn awards up to $100,000 for phase I and up to $750,000 for phase II. Phase III looks to the private sector for funding. Successful bidders can be awarded up to $100,000 to perform a feasibility study as phase I. If the small firm and the agency then agree, the firm can be awarded a phase II contract or grant for actual R&D resulting in a model or prototype. In the third phase—commercialization—the small firm is encouraged to bring the innovation to market.

At the completion of the second phase the government has the rights to the innovation for its own use only; that is, the government will never pay the firm a royalty. But the small firm keeps all other rights to the innovation and is encouraged to patent, copyright, or take other measures to protect its position. The firm can then bring the innovation to the marketplace, producing the product or service directly or working out co-venturing or licensing arrangements.

By some measures the SBIR program has been highly successful. Since its inception in FY 1983, small high technology firms have submitted more than 220,000 proposals resulting in more than 33,000 awards. Although the program's primary purpose is to meet the government's R&D requirements, the side benefit is substantial: more than 25 percent of SBIR projects have become products or services sold in the marketplace. The public reaps the benefits of the government research and the business participants improve their competitive positions and profitability.

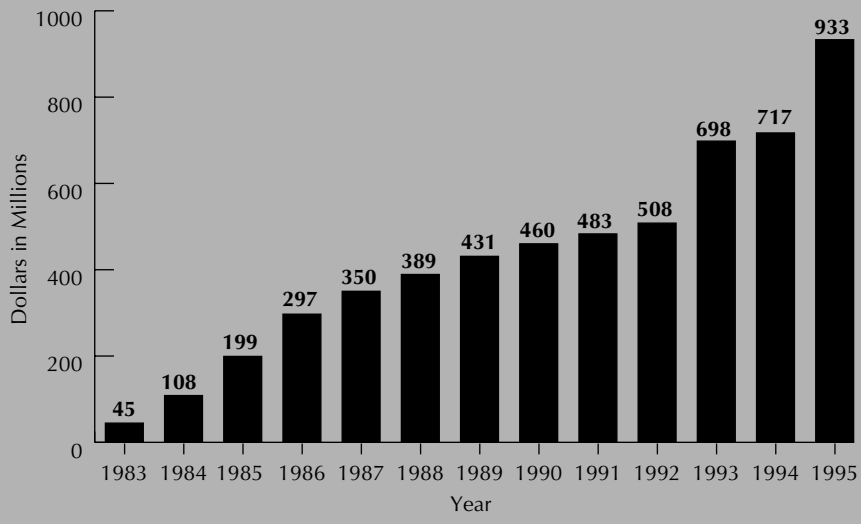
The SBIR program is meeting not only the research goals of the funding agencies, but also a special need for high-risk seed and start-up capital. The current level of almost $1 billion in SBIR funding each year is more than 10 times the funding provided by the institutional venture capital organizations to these small technology firms (Chart 5.2).[10]

SBIR at the Department of Defense

The Defense Department's (DOD) SBIR program funds early-stage R&D projects that serve a DOD need and also have the potential for commercialization in military and/or private sector markets. Three military services and four defense agencies participate in the DOD SBIR program: the Departments of the Army, Navy and Air Force, the Defense Advanced Research Projects Agency, the Ballistic Missile Defense Organization, the Defense Special Weapons Agency, and the U.S. Special Operations Command. The magnitude of the DOD SBIR program has grown from $240 million in FY 1992 to $450 million in FY 1995 (Chart 5.3).

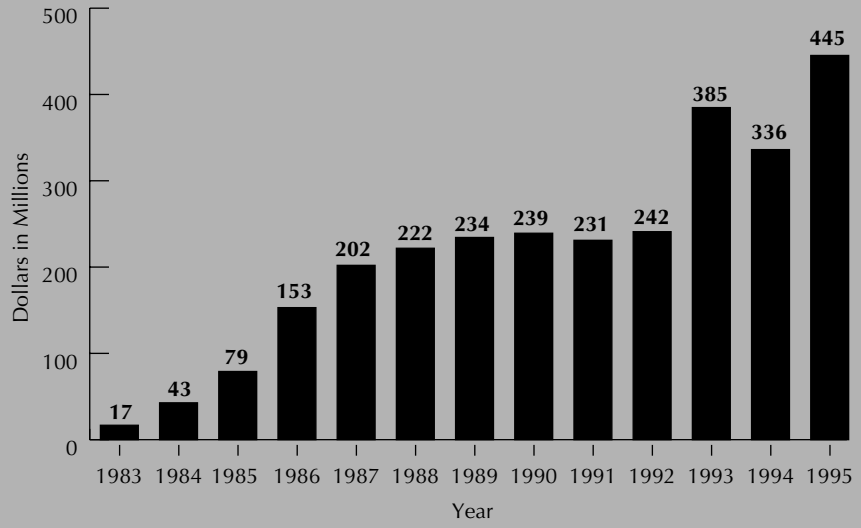
[10] Josh Lerner, "The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program," working paper 96-038 (Boston, Mass.: Harvard Business School, 1996). For an alternative view, see Scott Wallsten, "The Small Business Innovation Research Program: Encouraging Innovation in Small Firms?" Stanford University unpublished paper, August 1995.

Chart 5.2 *SBIR Program, Dollars Awarded, Fiscal Years 1983–1995*



Source: U.S. Small Business Administration, Office of Innovation.

Chart 5.3 *Department of Defense Small Business Innovation Research, Fiscal Years 1983–1995.*



Source: U.S. Department of Defense.

DOD's Recent Efforts to Streamline and Improve its SBIR Program.

DOD is pleased with the success of its SBIR program, but has also taken important steps to streamline and improve the program in response to congressional recommendations in the 1992 Small Business Innovation Development Act. In particular, Congress expressed concerns about reducing unnecessary delays in the SBIR contracting and payment process, and about increasing the focus of the SBIR program on commercialization of the research in military and private sector markets. Among the steps taken were the following:

- Establishment of the SBIR Fast Track. Under the Fast Track policy, DOD gives its highest priority for phase II awards, and for continuous funding between phases I and II, to those SBIR projects that attract matching cash from an independent third-party investor in phase II. That an independent third party is willing to make such a cash investment is a strong indication that: (1) there is a significant market (military and/or private sector) for the technology, and (2) the small company has not only the technical expertise, but also the business and marketing expertise, to bring the technology to market.

- Reduction of delays in the SBIR process. The DOD has set a goal of reducing the time between proposal receipt and award to four months in phase I and six months in phase II. In previous years, delays have averaged 6.5 months in phase I and 12 months between the end of phase I and the beginning of phase II. Such delays tend to bias the program against successful commercialization by making it difficult for start-up companies to keep their research teams intact and by lengthening the time to market.

- Enabling NTBFs to talk by telephone with the authors of SBIR solicitation topics. In both FY 1996 solicitations, DOD implemented a new "pre-release" policy enabling companies, before submitting a proposal, to talk by telephone with the author of the SBIR solicitation topic. The small business community greatly appreciates the new policy, because it enables companies to gain a greater understanding of DOD needs before they submit a proposal. DOD topic authors also support this policy: they anticipate that it will result in higher-quality SBIR proposals and fewer misguided proposals.

- Systematic measurement of the SBIR program's effectiveness in stimulating the development of successful new products. Starting in October 1996, all companies submitting phase I proposals are asked to complete an appendix showing, for each previous phase II award that the company has won: (a) the amount of non-SBIR funding received for commercialization of the research in military and/or private sector markets, and (b) the revenue from sales of new products resulting from the previous research. All companies winning phase II awards in fiscal year FY 1997 and thereafter will be asked to provide a brief annual report that also shows non-SBIR funding and sales revenues from new products.

The quality of DOD SBIR research since FY 1992 has kept pace with the program's expansion. Despite the significant increase in program expenditures, the 1995 GAO study, as well as DOD's own assessment in 1996, found no evidence of erosion in research quality since passage of the 1992 act. The ratio of funded to unfunded phase I SBIR proposals at DOD has remained relatively steady at roughly 12 percent since FY 1992 and, indeed, since the inception of the program. The increase in program expenditures has been offset by a significant rise in the number of SBIR proposals and an increase in the dollar value of the average SBIR award. This suggests that the SBIR proposal selection process at DOD remains highly competitive and that DOD has a large pool of proposals from which to select those with the highest technical and commercial merit.

DOD continues to have a large reserve of projects deemed worthy of funding by evaluation panels but receiving no award because of funding constraints. DOD scientists and engineers report that the overall quality of the SBIR research they monitor equals, and in some cases exceeds, the quality of the other agency research they monitor and that SBIR projects are substantially more likely than non-SBIR projects to lead to inventing and commercializing new products, processes, or services.

SBIR technology has made a major contribution to U.S. military and economic capabilities. While research quality is an important measure of success of the SBIR program, the ultimate measure is whether the program stimulates the development of new products that make a significant contribution to the mission of the funding agencies. A 1992 GAO study of commercialization of SBIR research found that DOD SBIR projects resulted in a number of affordable, high-performance new products of significant benefit to both DOD and the private sector (with commercial sales and additional funding of $410 million as of July 1991).[11]

DOD has several examples of SBIR-developed technologies that have resulted in significant improvements in U.S. military capabilities and major savings to the taxpayer. One example is the development of the "SaviTag."[12]

Savi Technology, Inc., Mountain View, California

Savi Technology recently developed the industry's first radio computer tag, the "SaviTag," using a combination of Navy SBIR funding and private venture capital. The SaviTag can be attached to military cargo containers or any other crate or container used for transport and will automatically track the container's location and contents. The SaviTag was developed with just $2.5 million in SBIR funding (three awards). It is a central element in DOD's Total

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[11] U.S. General Accounting Office, *Small Business Innovation Research Shows Success But Can Be Strengthened,* RCEB-92-37 (Washington, D.C.: U.S. General Accounting Office, March 1992).

[12] Another example is the "multipurpose processor" by Digital Systems Resources, Inc. A number of other examples are available at the DoD SBIR and STTR programs home page at http://www.acq.osd.mil/sadbu/sbir/.

Asset Visibility effort: the goal is to be able to pinpoint the location and content of every plane, ship, tank, and cargo container in transit around the world. In 1994, the Air Force awarded a $71 million contract to Savi, and DOD now uses the SaviTag in a large segment of its logistical operations, including almost all shipments into Bosnia.

During Operation Desert Storm in 1991, more than one-half of the 40,000 cargo containers shipped to the desert, including $2.7 billion worth of spare parts, went unused, according to a GAO report. The Army has estimated that if an effective way of tracking the location and content of the cargo containers, such as the SaviTag, had existed at that time, DOD would have saved roughly $2 billion. That is an enormous savings—far more than the entire annual SBIR budget. The SaviTag has already resulted in major efficiencies in U.S. logistical operations in Bosnia, although a precise estimate of the savings has not yet been made.

The SaviTag also has major applications in the private sector, particularly in the commercial trucking, rail, and shipping industries. Savi's sales to the private sector are projected to be between $5 million and $6 million in FY 1996, and they are increasing rapidly.

The National Science Foundation's SBIR Program

The National Science Foundation's (NSF) SBIR program offers opportunity and incentive for small and creative engineering, science, education, and technology-related firms to conduct innovative, high-risk research on important scientific and technical problems—work that could have significant public benefit if the research is successful. The NSF's SBIR program has received a good return on its investment in the small business community.

For both start-up and existing firms the receipt of an SBIR award was related to the firm's success in terms of sales, investment, employment, and patents. For example, a sample of 25 companies that received NSF SBIR awards after their founding had total employment of 490 at the time of the first award (Table 5.3). By 1995 total employment had increased to 7,904 jobs. More than 500 patents had been issued and 579 research collaborations related to SBIR had taken place. The following are examples of NSF's successful SBIR companies.

Relational Technology, Inc., Alameda, California

Relational Technology had a goal of providing distributed database technology for local area networks. The company (which later became Ingres Corporation) received a phase I award in 1981 and a phase II award in 1983.

The NSF's SBIR support contributed to a major technology breakthrough and commercial success. The research supported was the first distributed relational database software. The SBIR phase I results led to $1 million in venture capital in 1982, another $2.5 million in 1984, and $8 million in 1986 after Ingres proved a success in the marketplace; the company's success led to a $30 million initial public offering (IPO).

Table 5.3 *National Science Foundation Small Business Innovation Research Success Stories, 1977–1995 (Millions of Dollars)*

	Company	State	Year Founded	Year[1] SBIR Award	Field	SBIR Start-up	Critical Factor	Cumulative Sales Direct	Related Indirect	Total
1	Relational Technology\Ingres	CA	1980	1981	Software		X	500	2065	2565
2	Symantec Corporation	CA	1982	1979	Software	X	X	50	1950	2000
3	Flow Research Quest Integrated	WA	1979	1981	Machinery	X	X	250		250
4	RF Monolithics, Inc.	TX	1979	1981	Electronics	X	X	127		127
5	Aquatic Systems, Inc./Kent SeaFarms, Inc.	CA	1972	1982	Aquaculture		X	33		33
6	Collaborative Res., Inc./Gerome Therapeutics	MA	1961	1977	Genetics		X	50	60	110
7	Advanced Technology Materials	CT	1986	1988	Materials		X	10	40	50
8	Aurora Flight Sciences	VA	1989	1989	Unmanned Aircraft	X	X	10		10
9	Browning Engineering Co.	NH	1979	1980	Materials Coatings		X	50		50
10	Nova Automation Corp./DTM	TX	1987	1988	Rapid/Prototyping	X	X	40		40
11	Spire Corp.	MA	1969	1979	Artificial Joints		X	32	10	42
12	Scientific Measurements Systems, Inc.	TX	1979	1981	Tomographic Measurement	X	X	18		18
13	IDM Corp	TX	1988	1981[2]	Tomographic Measurement		X	16		16
14	Bend Research, Inc.	OR	1975	1977	Membrane Chemistry		X	23		23
15	Integrated Systems, Inc.	CA	1980	1981	Embedded Software	X	X	250		250
16	Lakeshore Cryotronics, Inc.	OH	1967	1981	Cryogenic Instruments			20	10	30
17	BioMetric Systems, Inc./BSI	MN	1979	1979	Bio Materials	X	X	1	200	201
18	Decision Science Corporation	VA	1978	1983	Decision Management		X	20	10	30
19	Charles Evans & Associates	CA	1980	1981	Instrumentation		X	45		45
20	Pritsher & Associates, Inc.	IN	1973	1981	Software		X	25	45	70
21	Helisys, Inc.	CA	1988	1989	Rapid Prototyping	X	X	33		33
22	Scientific Computing Associates	CT	1980	1985	Software		X	21		21
23	EPITAXX, Inc.	NJ	1984	1986	Optoelectronics		X	19	19	38
24	Crystal Systems, Inc.	MA	1971	1979	Crystals		X	5	100	105
25	Weidlinger Associates	CA	1949	1980	Mathematical Modeling		X	5	1	6
	Total					9	24	1653	4510	6163

[1] The National Science Foundation had a pilot SBIR program prior to passage of the Small Business Innovation Development Act in 1982.
[2] Spinoff of Scientific Measurements Systems from same NSF Project.
Source: U.S. National Science Foundation.

Percent	Investment			At First	Jobs			Patents Issued			Research Collaborations				
Export	Direct	Indirect	Total	Award	Now	Via. JV, SO. License	New Jobs	U.S.	Foreign	Total	Industrial	Univ.	National Lab	Other	Total
50	42	30	72	6	2000	525	2519				2	1	7		10
10	14	164	178	6	2000		1994					1			
	27														
20	27		27	50	96	792	838	3		3	9	18	5	3	35
50	26		26	5	470		465	28	50	78	1	3	1		5
5	9		9	7	70		63				6	6	2	5	19
10	36		36	33	100	160	227	10	25	35	18	2		1	21
	1	46	47	22	170		146	12	12	24	50	100			150
	3		3	3	94		91				1	6	6		13
30				8	1		7	10	24	34	2		1		3
40	43		43	4	100		96	26	1	27	1	1		1	3
5				90	150		60	7		7	30	30	25	24	109
20	8		8	13	18		5	4	1	5	4	2	4	1	11
	4		4		28		28	6	72	78	1	1			2
10	2		2	10	70	160	220	55	62	117	4	7	1		12
33	13		13	18	450		439	4	4	8	2	3	1		6
45				45	110		65	3		3	2	6	2	1	11
20	6	7	13	3	70		67	10	49	59	40	28	2		70
				8	35		27					6	8		14
50	5		5	10	130		120	4	4	8	2	3	1		6
30	1		1	33	50		17				2	3			5
45	7		7	1	102		101	2	3	5	2				2
15	1		1	8	15		7				9	8	3		20
60	13		13	5	182		177	1	1	2		3			3
10	4		4	12	25		13	2	8	10	12	12	6		30
15				90	200		110				10	6	2		18
27	265	247	512	490	6736	1637	7904	187	316	503	210	256	77	36	579

The president of Relational Technology during the rapid-growth period credits the SBIR program with providing "critical seed capital," which ultimately led to the success of the product and was key to the product's early edge to market. Customers for this first-to-market product included more than 100 Fortune 500 firms, such as Boeing, General Motors, British Airways, NASA, DOD, and all the national laboratories. Ingres also played a major role in the success of Boeing's AWACS aircraft and its considerable contribution to airborne surveillance during the Gulf War.

Cumulative sales directly and indirectly attributable to the SBIR program total $1.8 billion, and employment has grown from six to 1,440 employees. The company, which was acquired in 1990 by ASK Computer Systems, collaborated in its research with the University of California at Berkeley.

Flow Technology, Inc., Kent, Washington

Flow Technology, Inc., which became Quest Integrated, Inc., sought to create an abrasive-waterjet cutting system. The company received 1981 phase I and 1982 phase II SBIR awards.

Quest Integrated, Inc. is now the world leader in high-pressure waterjet cutting tools and it attributes this leadership to NSF and other agency-funded SBIR research. NSF's Research Applied to National Needs (RANN) program funded the company's early research on ultra high-pressure waterjet cutting tools prior to the SBIR program.

In 1981, NSF SBIR funding resulted in Flow Research's major improvement in waterjet cutting tools with the addition of carbide bits and other abrasives to the waterjet cutting stream, which allowed the cutting of steel, ceramics, and glass. The firm quickly became market leaders in the high-pressure waterjet cutting-tool field with about 70 percent of the market. Sales from the new technology, mostly from precision, metal and composite-cutting machine tools, total $250 million; exports represent 20 percent.

Major clients include GE, Corning, Kodak, Lockheed, Rockwell, and Allied Signal. Quest attracted $35 million in private capital, and 838 new jobs have been created directly from the new technology the SBIR program supported. The firm has research collaborations with 18 universities, four national laboratories, and four major U.S. industrial companies.

Intellitools, Inc., Novato, California

Intellitools applied for SBIR funding to adapt software and curricula for students with disabilities. The company received a 1992 phase I SBIR award and a 1994 phase II award.

The NSF's SBIR award has resulted in the creation of several products that meet the needs of students with disabilities in improving their science and math skills. As a result of the SBIR support, a commercial product has emerged. "Click-It" allows users to point and click on the computer screen without having to manipulate a mouse. More than 250 of the product were sold in the first month after its introduction.

In addition to creating both a new product and a new marketplace for technology serving the disabled community, the company has seen a 400 percent increase in sales, received numerous new product awards, and increased its employment from 7 to 18.

The Small Business Technology Transfer Program

The Small Business Technology Transfer Program (STTR) is a three-year pilot program, funded in 1994 through a small allocation from five federal agencies' extramural R&D budgets.

The purpose of STTR is to tap research institutions for the enormous reservoir of ideas that have not yet been deployed effectively for the nation's economic benefit. These research institutions employ one in four R&D scientists and engineers in the United States and perform more than $40 billion in R&D each year. They have helped position the United States as undisputed world leader in basic research and many areas of applied research.

The one-quarter million scientists and engineers in these institutions often recognize that their research has important commercial applications, but few have efficient mechanisms to pursue these applications.

STTR is an important step toward harnessing this research for America's economic advancement. By merging the innovative ideas of the researcher at the research institution with the entrepreneurial skills of a small technology company, STTR creates an efficient vehicle for moving the ideas to market. University collaboration with new technology-based firms has the potential to stimulate innovation more than R&D performed solely in a company lab.[13] Route 128 in Massachusetts and Silicon Valley in California are centers of high-tech economic development precisely because of university interaction with small, innovative companies.[14]

Both STTR and SBIR programs serve the purpose of transforming innovative research into commercial reality. STTR uses the approach established in the SBIR program, which has proven remarkably efficient in stimulating technological innovation. But whereas SBIR funds R&D projects at small firms and limits the participation of research institutions to a subcontracting or consulting role, STTR funds cooperative R&D projects between an NTBF and a research institution. STTR enables a researcher at a university to spin off a commercially promising idea by joining forces with a small technology company. Thus, STTR is a mechanism for small businesses to tap into the vast reservoir of ideas in the nation's research institutions.

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[13] Paul Almeida and Bruce Kogut, "The Exploration of Technological Diversity and Geographical Localization in Innovation: Start-up Firms in the Semiconductor Industry," *Small Business Economics*, Special Issue on Small and Medium-Sized Enterprises in the Global Economy, edited by L. Preston and C. Heller, vol. 9(1), 1997.

[14] Luc Anselin, Attila Varga, Zoltan Acs, "Local Geographic Spillovers between University Research and High Technology Innovations," *Journal of Urban Economics*, forthcoming.

The Advanced Technology Program

Small firms are thriving in the rigorous, hard-fought competitions of the Advanced Technology Program (ATP), which is managed by the U.S. Department of Commerce's National Institute of Standards and Technology (NIST). Of the 280 awards made by the ATP from 1990 to 1996, nearly half went to individual NTBFs or to joint ventures led by a small business. The awards are valued at $970 million in ATP funds and more than $1 billion in industry cost-share. Many more NTBFs are participating in or benefiting from the program as members of ATP-funded joint ventures, and as subcontractors, suppliers, and customers of ATP awardees.

And small means small in the ATP. Many of the awardees have been start-ups or still in the early development stages. More than half of the 100 small, single-company awardees had fewer than 25 employees and more than 85 had fewer than 100 employees at the time they received the ATP award (Chart 5.4).

In partnership with the ATP, these NTBFs are developing high-risk, enabling technologies that they can translate into new business opportunities, new industrial processes to improve their productivity and the productivity of other U.S. producers, and new products and services for the world's markets. Some of these technologies are pathbreaking in that they will revolutionize existing ways of doing things or create whole new industry sectors. Some provide the technical infrastructure critical to productivity advances within an industry sector. And some have many different uses across a variety of industry sectors.

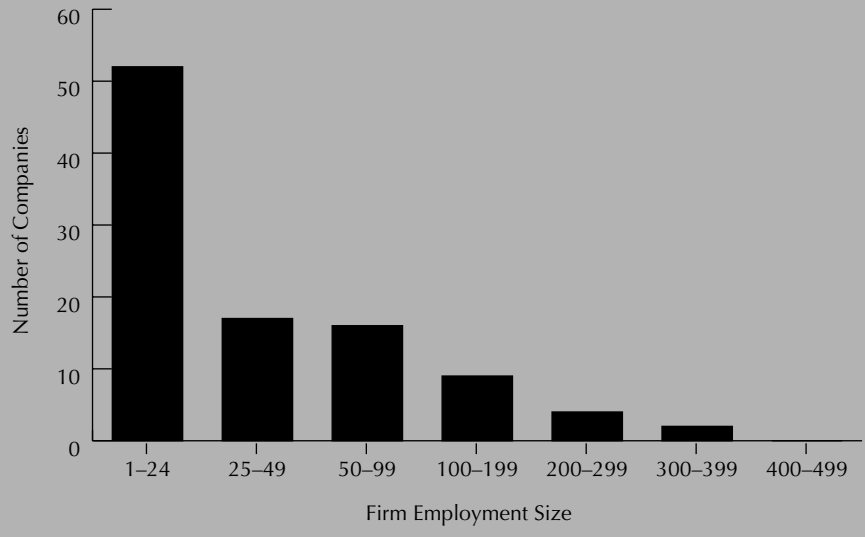
Aastrom Biosciences, Inc., Ann Arbor, Michigan

Aastrom Biosciences has developed new pathbreaking technology that may provide dramatically improved therapies for patients with cancer, AIDS, and genetic blood diseases. The company has completed a two-year ATP cost-shared project to develop a bioreactor that grows human bone marrow transplantable into human beings and is currently in clinical trials with the process.

When the company received its ATP award in 1992, it had about 15 employees and a laboratory process developed at the University of Michigan for growing human stem cells outside the body. Today, Aastrom Biosciences has 60 employees with another 30 on contract services, a clinical system that will allow hospitals to produce therapeutic bone marrow, blood, and immune system cells sufficient for patient treatment, and more than $36 million in additional investment capital raised from private investors to develop the bioreactor system into a commercial product.

Moreover, Aastrom Biosciences recently signed a $25 million alliance with a larger global pharmaceutical company to use the bioreactor system to produce human T-cells for treatment of cancer and infectious diseases. The firm has received patents for its bioreactor system, the first for replicating stem cells.

Chart 5.4 *Size Distribution of 100 Small Businesses Funded by the Advanced Technology Program*



Note: Chart refers to a total of 100 small single-applicant companies funded by the Advanced Technology Program from 1990 to 1996.
Source: U.S. Department of Commerce, National Institute of Standards and Technology.

Diamond Semiconductor Group, Gloucester, Massachusetts

Diamond Semiconductor Group (DSG) was a two-partner start-up in a converted barn when it applied for an ATP grant in 1992. The company has developed new process technology for the semiconductor industry that offers increased productivity and reduced cost as the industry advances to larger wafer sizes to accommodate increasingly complex integrated circuits. With the ATP award in hand, the tiny company attracted the attention of Varian Associates, one of the world's largest suppliers of ion-implantation equipment.

With ATP funding, DSG was able to demonstrate technical feasibility of its approach to ion implantation. With Varian Associates' subsequent funding for product development, DSG built a prototype ion-implant machine. As a result, DSG and Varian Associates announced, early in 1996, an "industry first"—successful ion implantation of a 300-millimeter wafer that offers two and one-half times the yield of the current industry standard 200-millimeter substrate, using DSG's new serial-process, high-current ion implanter technology.

Accuwave, Santa Monica, California

A 10-person fiber optic telecommunications start-up founded in 1990, Accuwave received an ATP award to pursue research toward developing a multiwavelength multiplexing system that would increase the capacity of a single optical fiber many times over current practice. The company successfully completed its ATP research project and has developed early spinoff products for sale to major telecommunications companies while it continues to develop the switching system based on the core results of the ATP project. The market for multiwavelength multiplexing was valued at $50 million in 1995 and is expected to grow to $2 billion by 2000.

These are just a few of the many examples of how small company recipients of ATP awards are developing the enabling technologies of the future, improving the productivity and competitiveness of U.S. industry, contributing to the quality of life, and creating many new, exciting business opportunities—not just for themselves, but for others as well.

Based on the evidence to date, without ATP funding, the companies either would not have developed the new technology at all or would have developed it at a substantially slower pace.[15] A recent survey of 125 companies that participated in ATP projects during the first three years of the program found that 64 percent of the small companies said chances were slim to nonexistent that they would have pursued the technology development at all without the ATP. Of the 36 percent of small companies that said they would have gone ahead anyway, 90 percent said their progress would have been significantly slower and 95 percent said their goals and level of effort would have been scaled back significantly without the ATP award (Chart 5.5).[16]

Acceleration of technology development by NTBFs is an important effect of the ATP. According to the survey, 94 percent of small-company award recipients believe they are further along as a result of their award. Seventy percent of these estimated that their work had been accelerated by at least two years.[17] Bringing the new technologies to fruition faster can be important in capturing world markets and realizing the benefits.

Many of the smallest companies are unknown at the time they receive an ATP award. Winning an award in ATP's stiff competition involving rigorous

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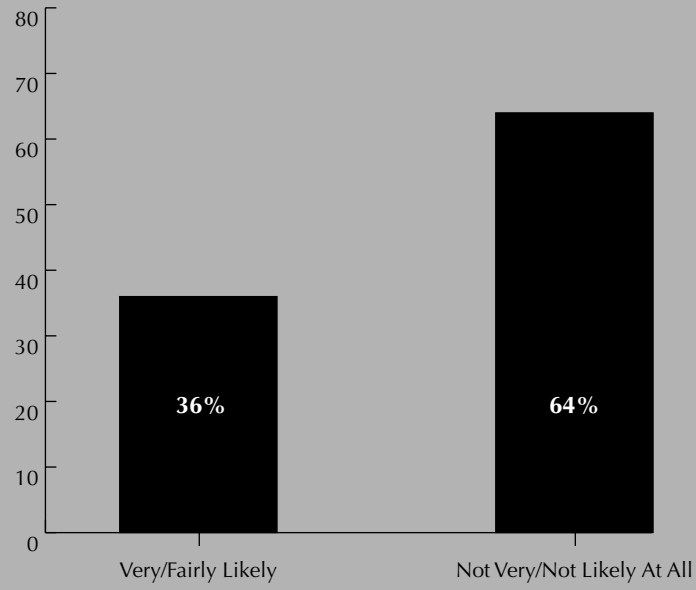
[15] Silber & Associates, *Survey of Advanced Technology Program 1990-92 Awardees: Company Opinion about the ATP and its Early Effects*, January 30, 1996; U.S. General Accounting Office, Report to the Ranking Minority Member, Committee on Science, House of Representatives, *Measuring Performance, The Advanced Technology Program and Private-Sector Funding*, GAO/RCED-96-47, (Washington, D.C.: General Accounting Office, January 1996); and Solomon Associates, *The Advanced Technology Program; An Assessment of Short-Term Impacts: First Competition Participants*.

[16] Silber & Associates, memo report to the ATP showing a breakout of percentages for small business based on the survey data reported in *Survey of Advanced Technology Program 1990-92 Awardees: Company Opinion about the ATP and its Early Effects, January 30, 1996*.

[17] Silber & Associates, acceleration reported by small businesses in the original survey and broken out in a memo to the ATP, August 14, 1996.

Chart 5.5 *Likelihood of Small Businesses Developing Their Technology without an Advanced Technology Program Award*



Source: U.S. Department of Commerce, National Institute of Standards and Technology.

scientific and business review serves to validate the potential worth of the technologies. Ninety-one percent of small companies in the recent survey believed that they had benefited to a "great" or "moderate" extent from enhanced credibility as a result of their ATP award. Most often they cited gains in credibility within their industry and business community, among their customers, investors, and scientific peers.[18]

Small-company recipients of ATP awards have also reported significant benefits from engaging in new collaborative relationships fostered by participation in ATP projects. These benefits extend not just to those companies engaged in formal joint research ventures, but also to the many single-company awardees that collaborate through subcontractor arrangements and informal alliances. Ninety-six percent of all those reporting collaborations rated them as being of "great" or "moderate" benefit. Some of the alliances were with other small companies, some were with universities, and some were with

[18] Silber & Associates, credibility gains reported by small businesses in the original survey and broken out in a memo to the ATP, August 14, 1996.

medium-sized to large companies. One of the effects noted by small companies was that the ATP provides them "a platform for demonstrating their merit to large corporations, paving the way for future business together."[19]

Although most of the ATP-funded projects are still in their early stages, the participants, including the small companies, have begun to report promising results. The ATP awards are enabling these companies to pursue challenging research projects that otherwise would have been delayed, scaled down, or not done at all. As a result, many of the companies now have important new technical capabilities that enable them to attract other sources of capital and pursue new commercial opportunities. Some are growing rapidly. New and improved processes, products, and services are emerging that benefit not just the award-recipient companies but also other researchers, producers, consumers, and, ultimately, the nation.

The Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP) is a growing nationwide system that gives smaller manufacturers unprecedented access to new technologies, resources, and expertise. At the heart of the system is a network of affiliated, locally based manufacturing extension centers. Each center is a partnership, typically involving federal, state, and local governments; industry; educational institutions; and other sources of expertise, information, and funding support.

Centers are private, nonprofit organizations rather than offices of the federal government. The program began with three extension centers in 1989. Today, nearly all states and Puerto Rico have or are planning centers affiliated with MEP, linking firms with engineers and other specialists with manufacturing or business experience to address specific needs (Table 5.4). Through this network, MEP is putting hard-to-find technical assistance and the newest business practices within the reach of the nation's 381,000 small and medium-sized manufacturing establishments.

What Does NIST/MEP Do?

In 1988, Congress directed the National Institute of Standards and Technology (NIST) to begin helping the nation's smaller manufacturers adopt and apply performance-improving technologies as needed to meet intensifying domestic and global competition in manufacturing. An agency of the U.S. Department of Commerce Technology Administration, NIST was selected for this role because of its expertise in manufacturing engineering and its longstanding tradition of productive partnerships forged with public and private organizations at the national, state, and local levels.

[19] Silber & Associates, *Survey of Advanced Technology Program 1990-92 Awardees*, 26.

Table 5.4 *Manufacturing Extension Partnership Activities and Impacts as of 1996*

Activity Data in a Nutshell. . .	
State planning grants to date	More than 40
Extension service partnerships	78 cooperative agreements
Geographical accessibility	100 percent of small manufacturers
State penetration	50 states and Puerto Rico
Average annual market penetration	7 to 10 percent
Total clients served since 1989	44,762
Median firm size	48 employees

Source: Silber and Associates, 1996.

To carry out this role, NIST/MEP conducts a variety of regional, national, and program development activities. Regionally, MEP works with the states or local organizations to establish manufacturing extension centers or expand existing services that assist smaller manufacturers. Many centers were cultivated through MEP's State Technology Extension Program (STEP). Beginning in 1990, STEP supported 32 states in building manufacturing extension programs.

MEP's activities also include helping foster a more unified network by working with centers to identify and coordinate the services, technology, and information needed at a national scale. MEP is developing a uniform system to help centers evaluate and continuously improve the success of services they deliver. To increase the breadth and depth of capabilities at each center and of the entire network—always with the goal of improving access for smaller manufacturers to public and private-sector resources—MEP and the individual centers have developed relationships with nearly 700 organizations. Among these partners are nonprofit technology or business assistance centers, nontechnical schools, private consultants, universities and four-year colleges, and federal agencies. To date, about half of the centers have ties to industry associations.

Developing working linkages with other organizations in support of the entire extension network also is a high MEP priority. For example, with the U.S. Environmental Protection Agency, MEP recently launched a program aimed at helping smaller manufacturers solve environmental concerns in the most cost-effective manner before they become problems requiring regulatory or compliance action. Other strategic partners include the National

Governors' Association, the National Alliance for Business, and the Council for Adult and Experiential Learning.

MEP is now in a position to make a significant contribution to the health of the economy. A major priority for MEP will be to sustain and strengthen extension center coverage and the effectiveness of services delivered to companies as they upgrade their equipment, processes, and practices to improve capabilities, performance, and prospects for growth.

This effort will require enhancing and augmenting network and center core competencies in service categories responsive to the most pressing challenges confronting significant numbers of smaller manufacturers. For example, MEP is strengthening ties with the NIST Baldrige National Quality Program and state-based quality outreach efforts to foster continual product and process improvement through the adoption of quality management concepts by smaller firms.

Extending the network's reach is also critical. Currently, established centers and field offices provide assistance to between 7 and 10 percent of potential manufacturing customers in their service areas. The program's five-year goal is to reach 15 percent, so that each year more than 55,000 smaller U.S. manufacturers are capitalizing on the resources and capabilities of MEP.

In consultation with manufacturers and center managers, MEP has identified three major programmatic priorities requiring sustained, concerted effort throughout the network—areas that will determine whether smaller manufacturers will be able to perform up to the standards of 21st century competition. The three themes—information technology, supply-chain optimization, and infusion of advanced technology—are integrally related. Increasing the information technology acumen of smaller manufacturers, for example, is essential if these companies are to be full participants in the dynamically integrated, yet reconfigurable, networks of suppliers, factories, distributors, and retailers that will characterize manufacturing enterprises of the future. Whether in the form of intelligent controllers, real-time sensors, or process-planning software, information technology also will be a fundamental ingredient of the shop-floor equipment that smaller manufacturers will be investing in to enhance their manufacturing and business performance.

What Services Do MEP Centers Provide?

MEP extension centers are designed to help link sources of improved manufacturing technology with the small and mid-sized companies that need them. Center staff work with individual companies or with groups of companies organized around common needs, industries, or technologies.

While each center tailors its services to meet the needs dictated by its location and manufacturing client base, most extension centers offer some common services. These include helping manufacturers to assess their current technology and business needs, define avenues for change, and implement improvements. Working with other federal, state, or local organizations, many

centers also assist companies with quality management, work force training, workplace organization, business systems, marketing, and financial issues.

Centers encourage client companies to establish programs for continuous improvement and to focus on long-term, bottom-line impacts, rather than working just to solve an immediate problem. All centers rely on experienced field agents and private consultants who provide the companies with on-site advice and practical assistance. Since 1989, MEP centers have provided services to more than 44,762 companies. Most of the MEP clientele are small companies with fewer than 100 employees (Table 5.5)

MEP Success Stories

MEP's locally managed centers have worked with thousands of smaller manufacturers, providing the technical and business assistance the companies needed to turn their businesses around. The following examples show how companies have benefited by working with a MEP center.

TECSTAR, Inc., City of Industry, California

A producer of space solar arrays and power subassemblies used in satellites, TECSTAR, Inc., wanted to cut down on solar cell breakage and reduce costs while increasing production and yields to keep up with increased sales. TECSTAR requested the assistance of the California Manufacturing Technology Center (CMTC) to improve its process. With CMTC's help, TECSTAR was able to save $3 million annually, increase staffing by 56 employees, reduce reactor downtime by 15 percent, and improve cycle time by 10 percent. "CMTC's recommendations to reduce solar cell mechanical breakage cycle time made us realize where the major dollar losses were occurring within our production processes," said Mark Shumaker, director of quality and production support. The $3 million savings equals the amount the CMTC received in FY 1995 from NIST.

Chicago Metal Rolled Products, Chicago, Illinois

Chicago Metal Rolled Products (CMRP) bends, rolls, and coils metal, producing structural elements for such major projects as the International Terminal at O'Hare Airport, the McCormick Place expansion, and the Navy Pier renovation. The Chicago Manufacturing Center (CMC) helped Chicago Metal President George Wendt institute a company-wide learning program involving basic reading, language and math skills, and job training. Wendt believes his investment in work force development is key to the company's growth. Over the past two years, CMRP has seen a 30 percent increase in sales and 20 percent growth in employment.

Technology Policy and the Information Revolution

One area having as much impact on NTBFs as the new global marketplace is technology and how it is thoroughly changing the way small firms do busi-

Table 5.5 *Size of Clients Served by the Manufacturing Extension Partnership, July–December 1995*

Firm Employment Size	Percent of all Clients
1 to 20	32
21 to 50	22
51 to 100	18
101 to 200	14
> 200	14

Based on 26 centers reporting in semi-annual report activity data logs, July–December, 1995.

Source: Silber and Associates, 1996.

ness. The small business community has been in the forefront of innovation and has created a new generation of high-skill, high-wage jobs.

The 1995 White House Conference on Small Business attendees recommended that development of the National Information Infrastructure (NII) be accelerated, that intellectual property rights be protected, and that technology commercialization investment for NTBFs be expanded.

To further these goals, the Clinton Administration has proposed a number of initiatives. For example, the National Institute of Standards and Technology and the Environmental Protection Agency have developed and funded programs to encourage private sector technology education and training. And there have been other administration and congressional initiatives:

SBIR Program Expansion

The Small Business Innovation Research (SBIR) program has nearly doubled its awards to NTBFs under the Clinton Administration, up from $508 million in 1992 to more than $900 million in 1995. By law, the percentage of federal research and development contracts going to small firms increased from 2.0 percent to 2.5 percent in 1996.

Intellectual Property and U.S. Trading Partners

The administration has taken aggressive action in international trade negotiations by the U.S. Trade Representative and by the Department of Commerce to ensure that the intellectual property rights of U.S. companies are adequately protected by America's foreign trading partners.

SBIR Proprietary Information

The SBA's Office of Technology is developing procedures in conjunction with the Small Business Innovation Research funding agencies to provide uniform protection of proprietary information provided under the SBIR program.

Standardized Scoring of SBIR Proposals

The SBA's Office of Technology is working with the SBIR funding agencies to encourage standardized scoring and evaluations of proposals to meet applicable commercialization evaluation criteria. The office is also working to develop consistent standards of indirect rate applications and to ensure that adequate administrative resources are provided for the SBIR program.

Manufacturing Extension Partnership

The Clinton Administration has expanded the Manufacturing Extension Partnerships (MEP) at the National Institute of Standards and Technology from seven to coverage in all 50 states in the last three years. The MEP program was included in the budget authorized by Congress for fiscal year 1996.

National Angel Capital Network

The SBA's Office of Advocacy has led an effort to develop an angel capital network. For more detail, see the section on SBA programs.

Conclusion

America's future economic growth is expected to be closely tied to the growth of new technology-based firms. Since 1980, the federal government has instituted a number of policies in support of these NTBFs, including the Small Business Innovation Research, Small Business Technology Transfer, and Advanced Technology programs, the Manufacturing Extension Partnership and several U.S. Small Business Administration financing programs for high technology companies.

While these programs represent only a small fraction of America's total investment in research and development, they have a significant impact. They represent a national commitment to encourage small technology-based businesses to address federal research needs and to create and commercialize new products and processes.